RHODACARIDAE (ACARI : MESOSTIGMATA) FROM NEAR ADELAIDE, AUSTRALIA. II. ECOLOGY

by D. C. LEE*

Summary

LEE, D. C. (1973).—*Rhodacaridae (Acari : Mesostigmata) from near Adelaide, Australia. II. Ecology. Trans. R. Soc. S. Aust.* **97**(2), 139-152, 31 May, 1973.

Serial collections of rhodacarid mites extracted by desiccating funnels from surface soil (greatest depth: 4 cm), moss and plant litter, at two sites on the western slopes of Mount Lofty, overlooking Adelaide, South Australia were studied, as were small collections of rhodacarids from two sites on the Adelaide Plain.

The presence of two communities of hemiedaphic rhodacarid mites is demonstrated by differences in the characteristic species of two sites and a significant association into two groups of the species of one subfamily (Ologamasinae). Population density is higher in the wet, cool winter and where there is substantial, decomposing plant litter. Variations are demonstrated between some species in the number of generations per year, the time for occurrences of particular life-history stages and the sex ratio. It is suggested that species of *Athiasella* prefer higher nutrient loamy soils, while *Gamasellus* is almost confined to low nutrient, sandy soils.

Introduction

Rhodacarids are mainly predatory mites, and are most common and diverse in form in Southern Temperate regions. The present work formed part of a study on rhodacarids from the environs of Adelaide, South Australia (Lee 1970[1]). Part I dealt with systematics (Lee 1973) and should be referred to for the authority to names of rhodacarids collected. Part III, dealing with behaviour, is to be published.

Most rhodacarids are hemiedaphic, being free-living in surface soil, plant litter, or in moss or other plants with a similar growth form. Some taxa, however, are not hemiedaphic. Thus, *Hydrogamasus, Litogamasus, Parasitiphis, Periseius* and *Tangaroellus* have only been found in or near the littoral zone, usually on rocky shores; *Rhodacaropsis* has only been found in the littoral zone on sandy shores; *Cyrtolaelaps* or *Euryparasitus* have generally been collected from bird or mammal nests or from bat caves; *Tangaroellus porosus* Luxton has usually been found under the carapaces of barnacles; and the two species of *Laelaptonyssus* have been found closely associated with flies or termites. Ecological studies demonstrating more limited habitat preferences include only non-hemiedaphic rhodacarid mites. Thus, *Hydrogamasus littoralis* (G. & R. Canestrini) mainly occurs in rock crevices in a limited part of the littoral zone(Glynne-Williams & Hobart 1952, Morton 1954). *Rhodacarus* and *Rhodacarellus* are commoner in the deeper soil layers (i.e. they are euedaphic) and are limited to parts of sampled areas (Sheals 1957, Davis 1963, Wood 1967a, Emberson 1968[2]). *Cyrtolaelaps* and *Euryparasitus* are commoner in mammals' nests that are on the ground and made of moss (Mrciak, Daniel & Rosicky 1966).

There is a problem in defining precise habitats for ground inhabiting mites, because a species may occur in strictly limited habitats,

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[1] LEE, D. C. (1970).—The taxonomy and general biology of the Rhodacaridae (Acari: Mesostigmata). M.Sc. thesis, University of Adelaide, Australia (unpublished).

[2] EMBERSON, R. M. (1968).—The Mesostigmata of certain coniferous forest soils in Western Quebec, with a preliminary account of North American Rhodacaridae (Acarina). Ph.D. thesis, McGill University, Montreal, Canada (unpublished).

but at widely differing localities. For instance, it has been shown in three different studies that *Rhodacarus roseus* Oudemans has a limited distribution. It occurred only in a limited area in mineral soil over iron-stone in grassland (Davis 1963); in non-calcareous drift around a limestone outcrop in moorland (Wood 1967a); and in alluvial saltmarsh (Luxton 1967). This type of distribution for a number of species of mite led both Davis (1963) and Wood (1967b) to suggest that many mite species consist of ecological races with different demands upon the environment and therefore occurring in quite different habitats.

The main aim of the present work was to demonstrate whether or not there are any habitat preferences amongst hemiedaphic rhodacarid mites. Incidental information on seasonal fluctuations of populations and life-histories was also sought. In addition, because species association was considered in relation to habitat preferences, the correlation between taxonomic affinity and degree of co-existence is discussed.

Four sites were initially sampled before two were selected for serial sampling. The results of the preliminary sampling from the two sites that were not sampled again are also given, because they suggest a possible correlation between certain genera and environmental factors.

Methods

Two extraction methods were used: one for dealing with disturbed "bag" samples collected throughout a year and the other for undisturbed "core" samples collected in August.

1. *Bag Sampling and Extraction*

Soil, down to a depth of approximately 4 cm, and the litter or moss on it, was scooped into a plastic bag with a trowel. The volume of a sample was about 1250 ml, and was taken from an area of approximately 250 cm². This sample was poured into an aluminium tube (14 x 40 cm) with a wire mesh bottom, which was placed on a coarser wire mesh in a funnel (diameter of mouth—22 cm) leading down into a glass vial of 75% alcohol. The sample was heated from above by a 40 watt electric light bulb for five days.

Bag samples were collected once a fortnight for a year (24.iv.1968–23.iv.1969). On each occasion four samples were collected between 11 a.m. and 4 p.m.; 2 from the Summit Site (Sc1 or S1), and 2 from the Foothills Site (Fc1 or F1)—see appendix. One sample of moss on soil and another of plant litter on soil were taken from each site. A total of 108 samples were collected in the series.

2. *Core Sampling and Extraction*

Steel core samples (5.15 cm diameter x 4 cm depth) were driven into soil covered by moss or litter, dug out, and then sealed by a lid at each end. The volume of each core was about 83 ml and from an area of approximately 20 cm². The steel cores, without lids, were inverted on wire mesh in multiple Tullgren funnels, so that the deepest part of the soil was uppermost. These funnels incorporated forced draught ventilation to prevent water condensation. The samples were heated from above by thermostatically controlled electric coils to 25° C for 2 days, followed by 30° C for 2 days, 35° C for 2 days and finally 40° C for 1 day.

Core samples were only collected on 5.viii.1968 and 12.viii.1968. On each occasion 16 cores were taken from points evenly spaced throughout each of 4 plots (S1, S2, F1 and F2)—see appendix to this paper. Samples from 2 plots (S2 and F1) were covered by a substantial layer of fermenting plant litter, and the other 2 plots (S1 and F2) were covered by moss and a little raw leaf litter. A total of 128 core samples were collected in the series.

Sites

Four sites were sampled between the summit of Mt. Lofty and the coast-line of the Adelaide Plain. In the appendix, the Summit and Foothills Sites which were extensively sampled are described in detail, while the Plains and Coastal Sites from which only small collections were made are given a briefer description. Two plots at each of the two former sites are also described.

Temperature and rainfall had linear gradients between the coast and Mt. Lofty: the former decreasing and the latter increasing with nearness to the summit. On the other hand, the Summit and Coastal Sites were similar in having low nutrient, sandy soils, in contrast to the higher nutrient, loamy soils of the two intervenient sites. Three sites had a predominately native flora, while the Foothills Site had an alien flora.

The sites that were extensively sampled (Summit and Foothills Sites) included areas which were either almost entirely covered by plant litter or similarly covered by moss. Core samples were only collected from rectangular plots in such uniform areas: one moss plot and one litter plot at each of the two sites. On the other hand bag samples were collected from larger areas including both plant litter and moss patches.

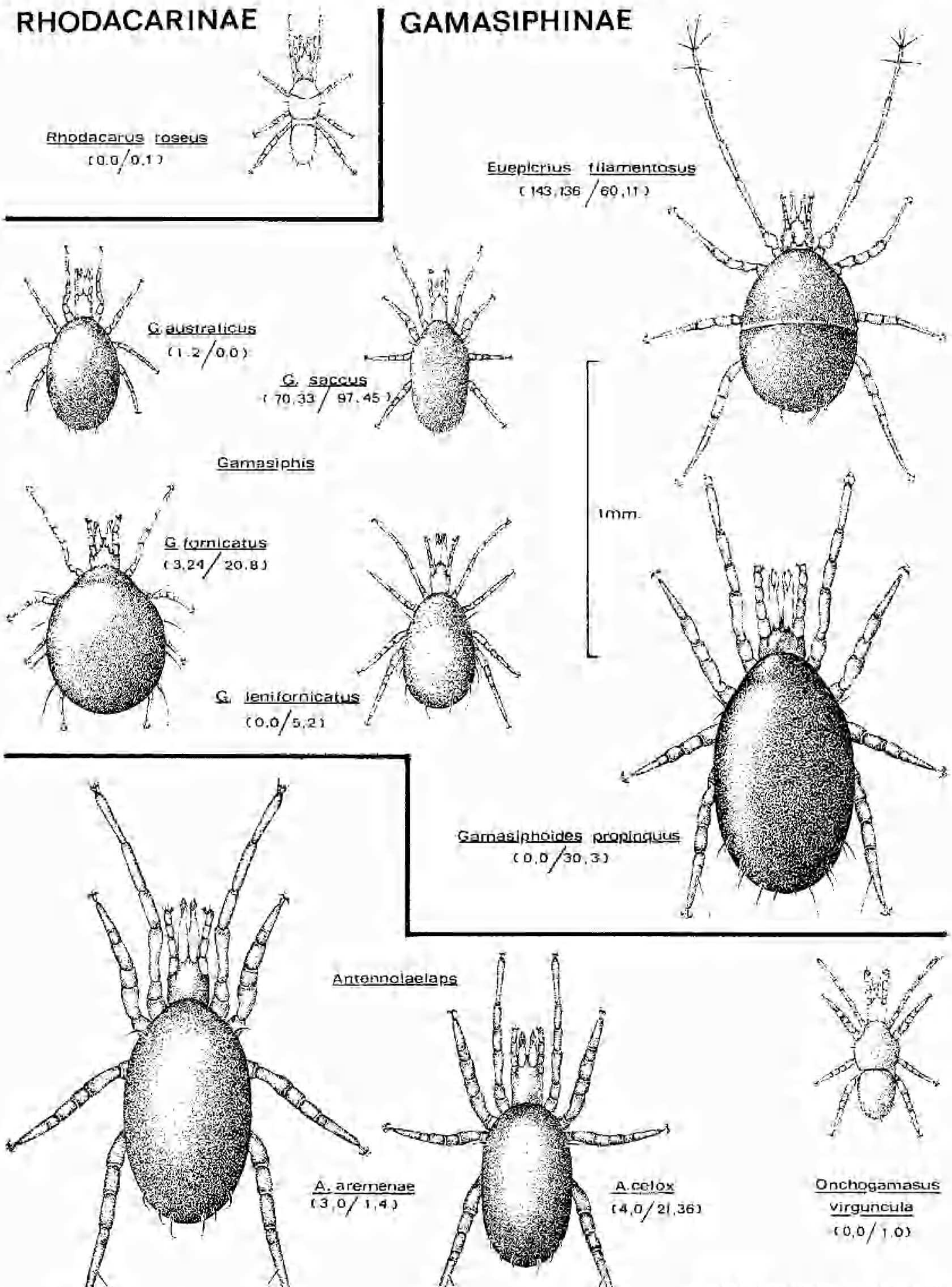

Fig. 1. Species of Rhodacarinae, Gamasiphinae and Sessiluncinae collected during serial sampling. Dorsal views of adult females. Numbers given under names equal specimens (any stage) from the following environments: (Foothills Site moss, FS litter/Summit Site litter, SS moss).

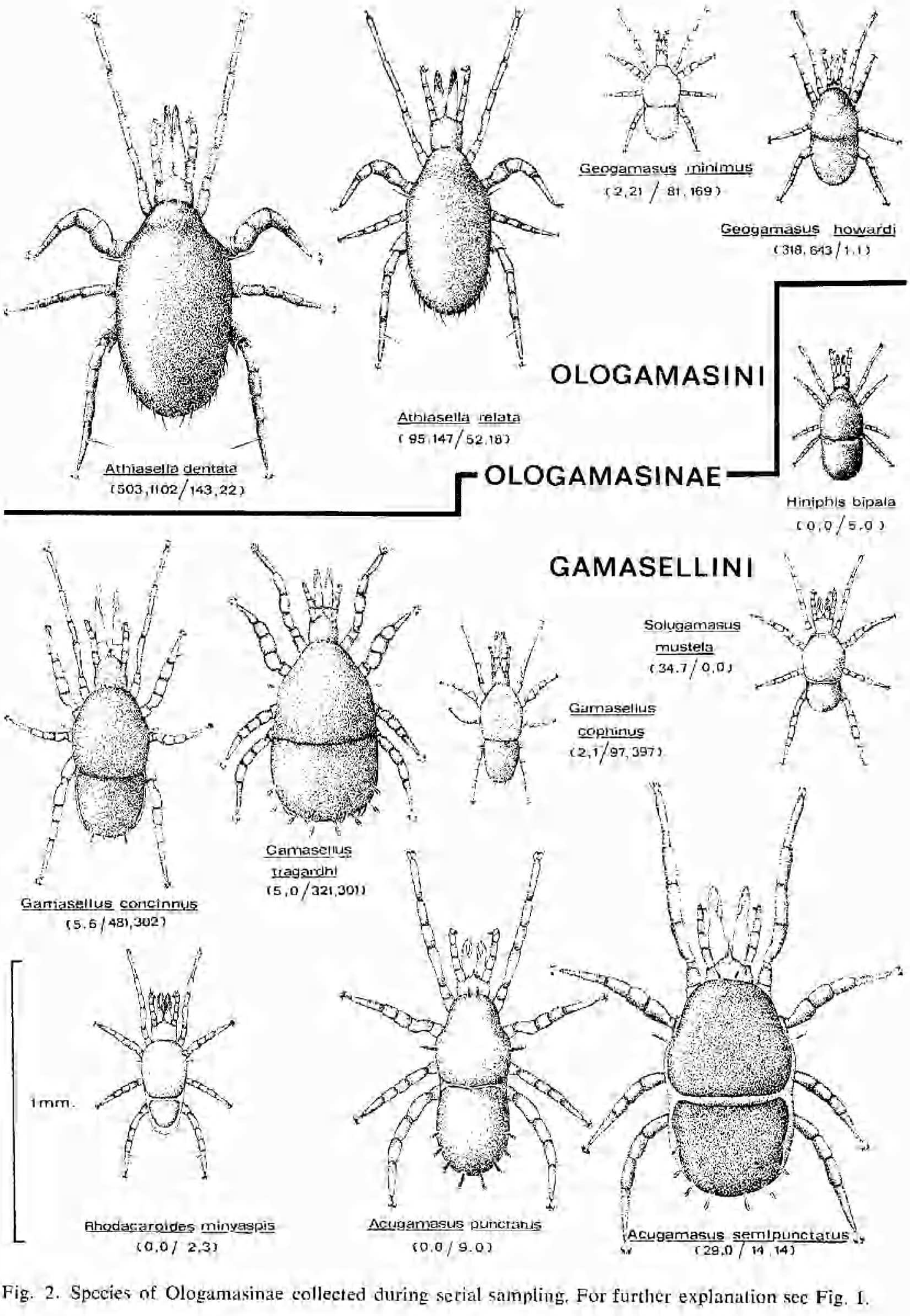

Fig. 2. Species of Ologamasinae collected during serial sampling. For further explanation see Fig. 1.

Results

1. *Species and forms represented*

Preliminary bag samples from the Plains and Coastal Sites in May and June, 1965, produced the following rhodacarids (number of specimens in parenthesis): Plains Site—*Rhodacarus roseus* (18), *Gamasiphis australicus* (4), *Athiasella dentata* (29); Coastal Site—*Gamasellus grossi* (13), *Acugamasus elachyaspis* (8). It would have been valuable to have proceeded with serial sampling at these two sites, but because of a time limitation this was only done at the two other sites which supported more rhodacarid species.

Sizes and collection dates of preliminary samples from the Summit and Foothills Sites were not comparable with those of the other two sites and are therefore not listed. Serial samples from the Summit and Foothills Sites produced twenty-two species of rhodacarids (Figs. 1, 2). A female *Rhodacarellus silesiacus* was listed (Lee 1973) from the Foothills Site, but this was taken while collecting mites alive for laboratory cultures. Such collections otherwise only included species taken in serial samples.

Only a small proportion of immature rhodacarids were collected. The 3 species for which results are presented (Figs. 6, 7) produced a relatively high proportion of these stages. Further comments on immature stages are made below under Section 5 (Seasonal Variation).

The sex ratio (male/female) of the 12 commonest rhodacarids from serial samples is as follows: *Gamasiphis fornicatus*, 0.26; *Acugamasus semipunctatus*, 0.33; *Geogamasus minimus*, 0.34; *Geogamasus howardi*, 0.41; *Gamasiphis saccus*, 0.45; *Gamasellus cophinus*, 0.56; *Gamasellus concinnus*, 0.66; *Antennolaelaps celox*, 0.67; *Gamasellus tragardhi*, 0.73; *Athiasella dentata*, 0.83; *Euepicrius filamentosus*, 0.84; *Athiasella relata*, 1.23.

2. *Differences between sites*

Numbers of specimens were as follows: Summit Site, 2784 (bag samples, 2137; core samples, 647); Foothills Site, 3340 (bag samples, 2707; core samples, 633).

Number of species were as follows: Summit Site, 20; Foothills Site, 15. The majority (13) of species were found at both sites, but there was a considerable difference in the composition of the fauna. This difference is demonstrated by presenting the dominance and frequency of the 12 commonest rhodacarids (Figs. 3, 4). *Dominance* is the percentage of the total specimens that belong to a species, and is represented by the size of a shaded area in a column. *Frequency* is the percentage of samples in which a species was found, and is represented by the numbers in the centre of a shaded area. Different species are characteristic (i.e. the most dominant and frequent) of different sites.

3. *Differences between soil cover of litter compared with moss*

Numbers of specimens were as follows: litter, 3558 (bag samples, 2696; core samples, 862); moss, 2566 (bag samples, 2148; core samples, 418). A similar indication is given if the results from the core samples alone are expressed as rhodacarids/m^2 as follows: Summit Moss Plot, 3450; Summit Litter Plot, 6660; Foothills Moss Plot, 3080; Foothills Litter Plot, 6810.

Numbers of species from Summit and Foothills Sites were as follows: litter, 21; moss, 19. The majority of species (18) were found in both litter and moss-covered soil. Comparing the dominance and frequency of individual species (Figs. 3, 4) it is evident that the species composition of a particular site is similar whether it is covered by litter or moss. The greatest differences are shown by the core samples when the whole plot was mainly covered by either litter or moss. Some species show distinct preferences: e.g. *Athiasella dentata* for litter; *Gamasellus cophinus* for moss. On the other hand, a preference at one site may be apparently reversed at the other site, e.g. *Geogamasus minimus*.

4. *Species Association (only Ologamasinae)*

Each site has different characteristic species (see Section 2), mainly belonging to the Ologamasinae. To establish whether or not two communities are present, the significance of associations in samples between species of Ologamasinae is examined. I have followed Debauche (1962) in using a correlation coefficient based on a contingency chi squared test as a measure of degree of association or dissociation of species.

The correlation coefficients from the results of bag samples (Table 1) produce the clearest pattern. Of the 28 terms, 18 are significant at the 1% level or less. The species fall into two groups. One group (*Athiasella dentata* and others) includes species characteristic of the Foothills Site. The other group (*Geogamasus minimus* and others) includes species characteristic of the Summit Site. Since *Athiasella dentata* and *A. relata* regularly occur at both

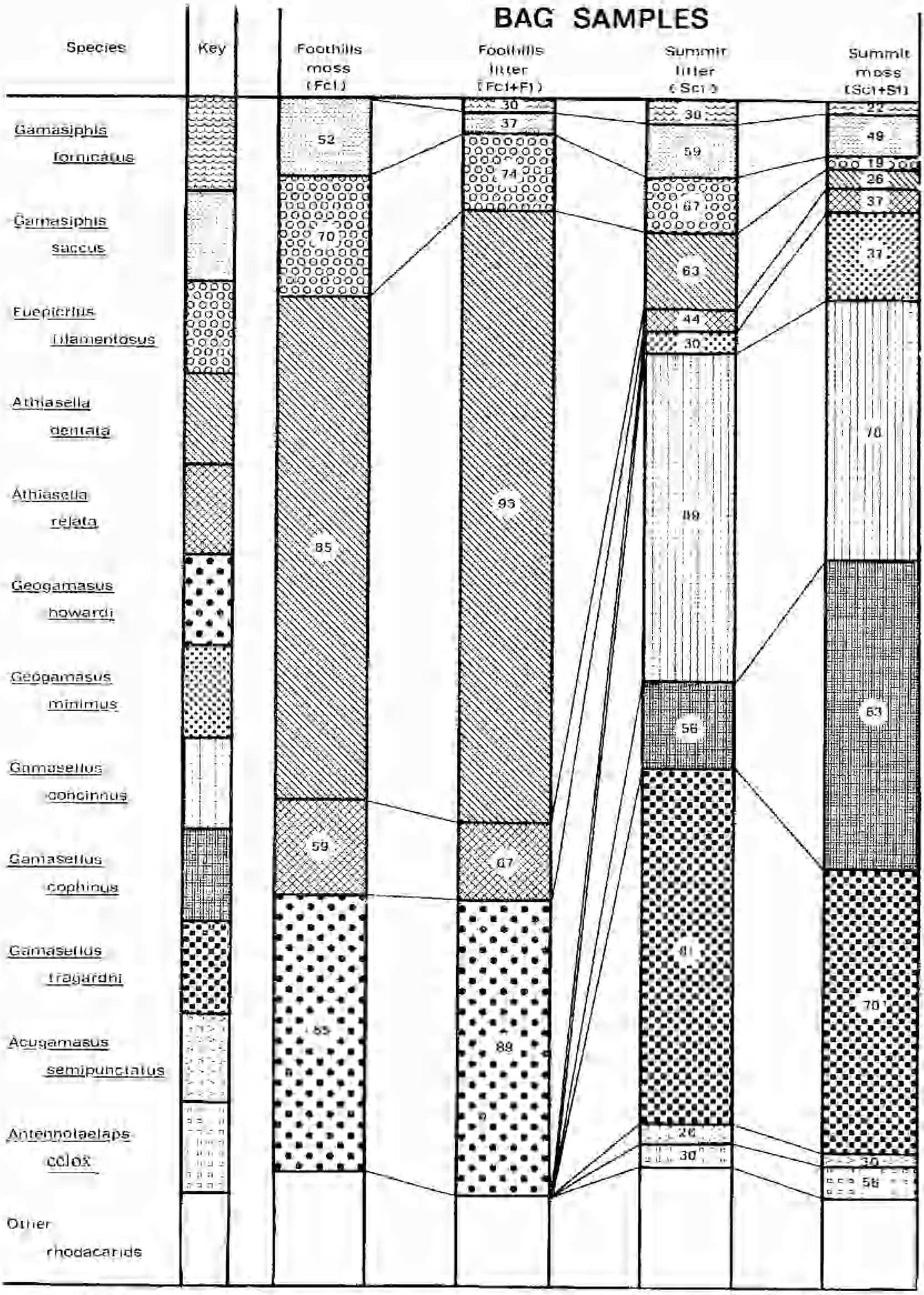

Fig. 3. The dominance and frequency of the 12 commonest species of rhodacarids in bag samples (collected from 2 sites throughout the year). For further explanation see text.

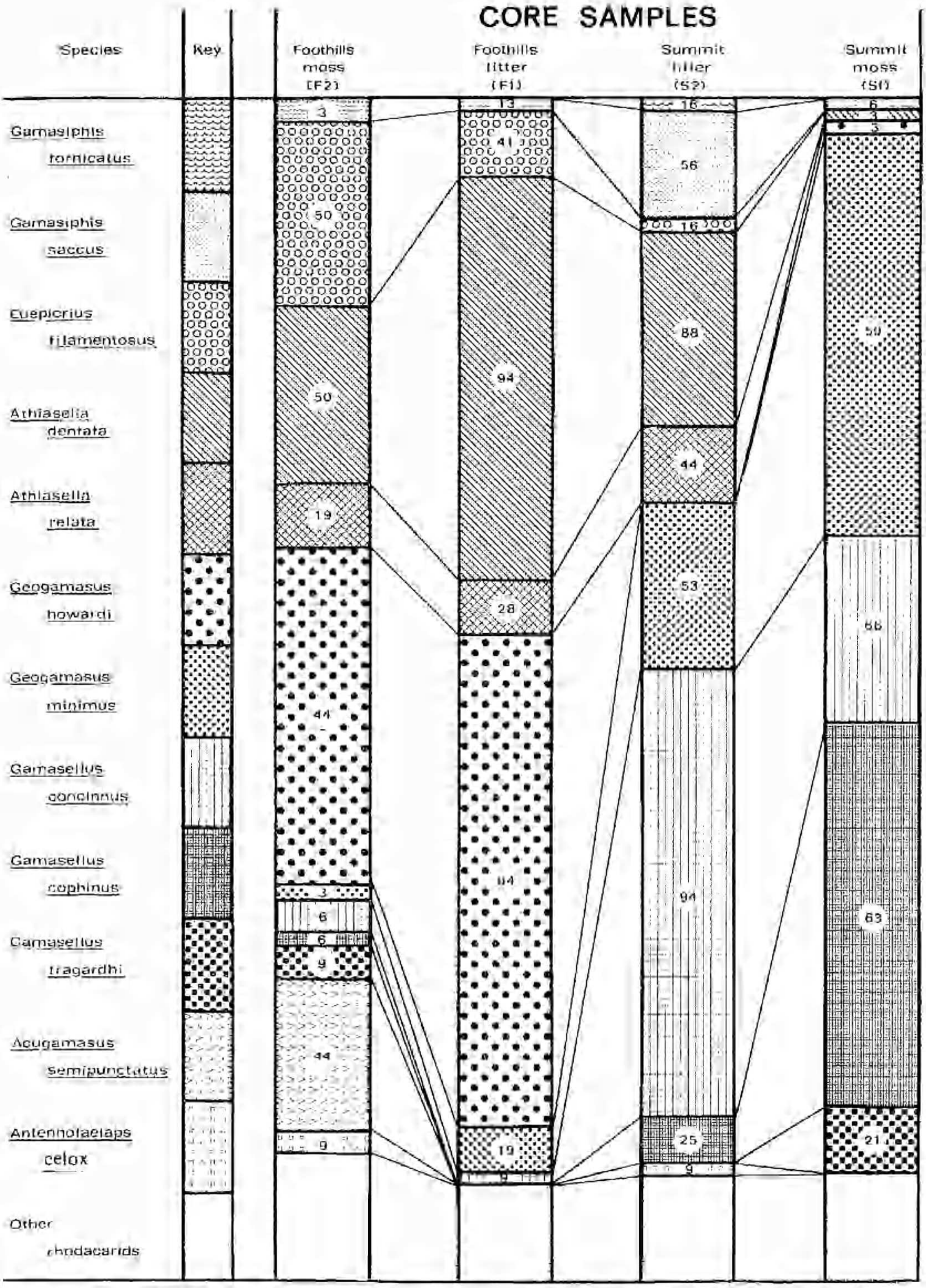

Fig. 4. The dominance and frequency of the 12 commonest species of rhodacarids in core samples (collected from 4 plots in early August). For further explanation see text.

TABLE 1.

Correlation of Ologamasinae species in 108 bag samples containing 4,844 specimens.
Correlation indices (C X 10³), + (association), — (dissociation), upper limit is 707.

Species	*A.den.*	*A.rel.*	*G.how.*	*G.min.*	*G.cop.*	*G.con.*	*G.tra.*	*A.sem.*
Athiasella dentata		+355	+448	—49	—142	—256	—197	—36
Athiasella relata	(***)		+307	0	+57	—32	—48	—14
Geogamasus howardi	(***)	(***)		—319	—495	—583	—566	—299
Geogamasus minimus	0	0	(///)		+517	+394	+399	+58
Gamasellus cophinus	0	0	(///)	(***)		+580	+598	+287
Gamasellus concinnus	(//)	0	(///)	(***)	(***)		+656	+396
Gamasellus tragardhi	—	0	(///)	(***)	(***)	(***)	(***)	
Acugamasus semipunctatus	0	0	(//)	0	(**)	(***)		+349

Significance of relations:

	None	Positive	Negative
P> 0.1	0		
P< 0.1		+	—
P< 0.01		(**)	(//)
P< 0.001		(***)	(///)

the Summit Site as well as the Foothills Site, there is, in the main, only a significant dissociation between *Geogamasus howardi* and species at the Summit Site.

The correlation coefficients from the results of core samples (Table 2) are similar to those of bag samples but with a drop in significant associations. Of the 28 terms, 12 (6 associations, 6 dissociations) are significant at the 1% level or less. Although there are the same number of significant dissociations, 3 are for different pairs of species. The reduction in associations is only significant where a pair of species was either uncorrelated or significantly associated in bag samples while being significantly dissociated in core samples. This was true at the 1% level or less for three pairs (*Athiasella dentata—Gamasellus cophinus, Athiasella dentata—Gamasellus tragardhi, Acugamasus semipunctatus—Gamasellus concinnus*). Such a significant dissociation in core samples could have had a number of causes: smaller sample size isolating niches; sampling separate moss or plant litter covered plots (one at each site was outside the area used for bag sampling), thus isolating niches and possibly introducing new ones; fewer mites per sample; no seasonal effects such as the absence of any rhodacarids from most summer samples. The conspicuous change in dominance between bag and core sampling of *Acugamasus semipunctatus* in "Foothills moss" samples and *Gamasellus tragardhi* in "Summit litter" samples suggests that the significant dissociation in core

TABLE 2.

Correlation of Ologamasinae species in 128 core samples containing 1,280 specimens.
Correlation indices (C X 10³), + (association), — (dissociation), upper limit is 707.

Species	*A.den.*	*A.rel.*	*G.how.*	*G.min.*	*G.cop.*	*G.con.*	*G.tra.*	*A.semi.*
Athiasella dentata		+355	+369	—106	—382	—24	—327	—205
Athiasella relata	(***)		+10	+49	—88	+87	—156	—35
Geogamasus howardi	(***)	0		—344	—309	—418	—203	+30
Geogamasus minimus	0	0	(///)		+213	+322	+161	—166
Gamasellus cophinus	(///)	0	(///)	+		+264	+236	—102
Gamasellus concinnus	0	0	(///)	(***)	(**)		—20	—231
Gamasellus tragardhi	(///)	—	—	+	(**)	0		+355
Acugamasus semipunctatus	—	0	0	—	0	(//)	(**)	

Significance of relations:

	None	Positive	Negative
P> 0.1	0		
P< 0.1		+	—
P< 0.01		(**)	(//)
P< 0.001		(***)	(///)

samples of the above pairs including these species is due to the difference in areas sampled. The same cause may apply for the dissociation between *Athiasella dentata* and *Gamasellus cophinus*.

5. *Seasonal Variations*

Seasonal fluctuation in total numbers of rhodacarids at each site based on bag sampling are summarised in Fig. 5. There was a conspicuous fall in numbers of rhodacarids in samples collected during the summer (December-February). This is associated with a drying out of the environment and rainfall figures for Stirling (5 km SSE of Summit Site) are given as a factor closely associated with this process.

The low number of samples taken means that seasonal differences indicated for the two sites are tentative. The number of rhodacarids from the Summit Site was fairly constant throughout the wetter months (May–November). At the Foothills Site the rhodacarid population apparently gradually increased in September and October to a peak, which was nearly twice the highest number at the Summit Site. If this change is true for the actual populations it could be related to the dominant genus at the Foothills Site, *Athiasella*, being multivoltine, while abundant species at the Summit Site are univoltine (see below).

Seasonal fluctuation in numbers of the different developmental stages and sexes of *Gamasellus concinnus*, *Gamasellus tragardhi* and *Athiasella dentata* are represented by histograms (Figs. 6, 7). Not enough immature

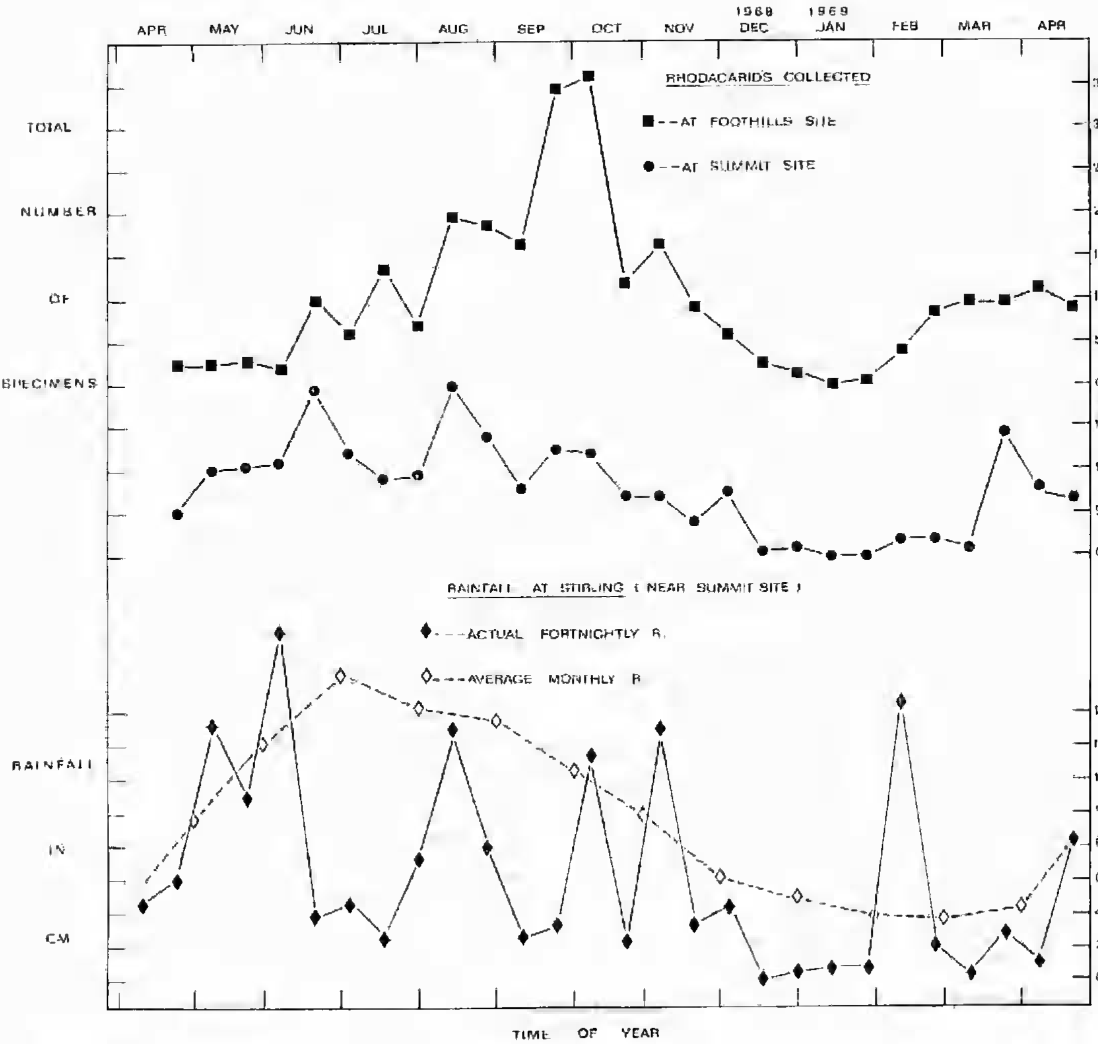

Fig. 5. Seasonal fluctuation in numbers of Rhodacaridae collected in bag samples at two sites during 1968 and 1969. Rainfall records are for nearby Stirling.

stages of the other rhodacarid species were collected to warrant presentation here.

In Canada, where the winter is extremely cold, *Gamasellus vibrissatus* (which is morphologically very similar to *G. tragardhi*) over-winters as adult females which give rise to a single generation in the following summer (Emberson—footnote 2). My results show that *Gamasellus tragardhi* (Fig. 6) has a similar life history, except that it over-summers as adult females and males which give rise to a single generation in the following winter. *Gamasellus concinnus* (Fig. 6) is also univoltine, but over-summers in the deutonymph stage, the males emerging before the females at the onset of the wet season. *Athiasella dentata* (Fig. 7) probably over-summers in the adult stage and it breeds for a longer period, probably being multivoltine. Results for some other species (Lee—footnote 1) are inadequate but suggest the kind of life-history that they have. *Geogamasus howardi*, *Athiasella relata* and *Euepicrius filamentosus* appear to have similar life-histories to *Athiasella dentata*. *Gamasiphis saccus* and *Gamasellus cophinus* may be univoltine and over-summer in the egg or early immature stages.

It is noteworthy that the life-histories indicate that there are large numbers of rhodacarids (e.g. deutonymphs of *Gamasellus concinnus*) in the soil during the summer that were not represented in the samples considered here. Possibly they move down deeper than the surface 4 cm sampled. There is no clear indication that rhodacarid species stagger their life-histories so as to avoid exploiting the environment concurrently.

Discussion

The twelve commonest species of rhodacarids in serial samples were found at both Summit and Foothills Sites, but each site had

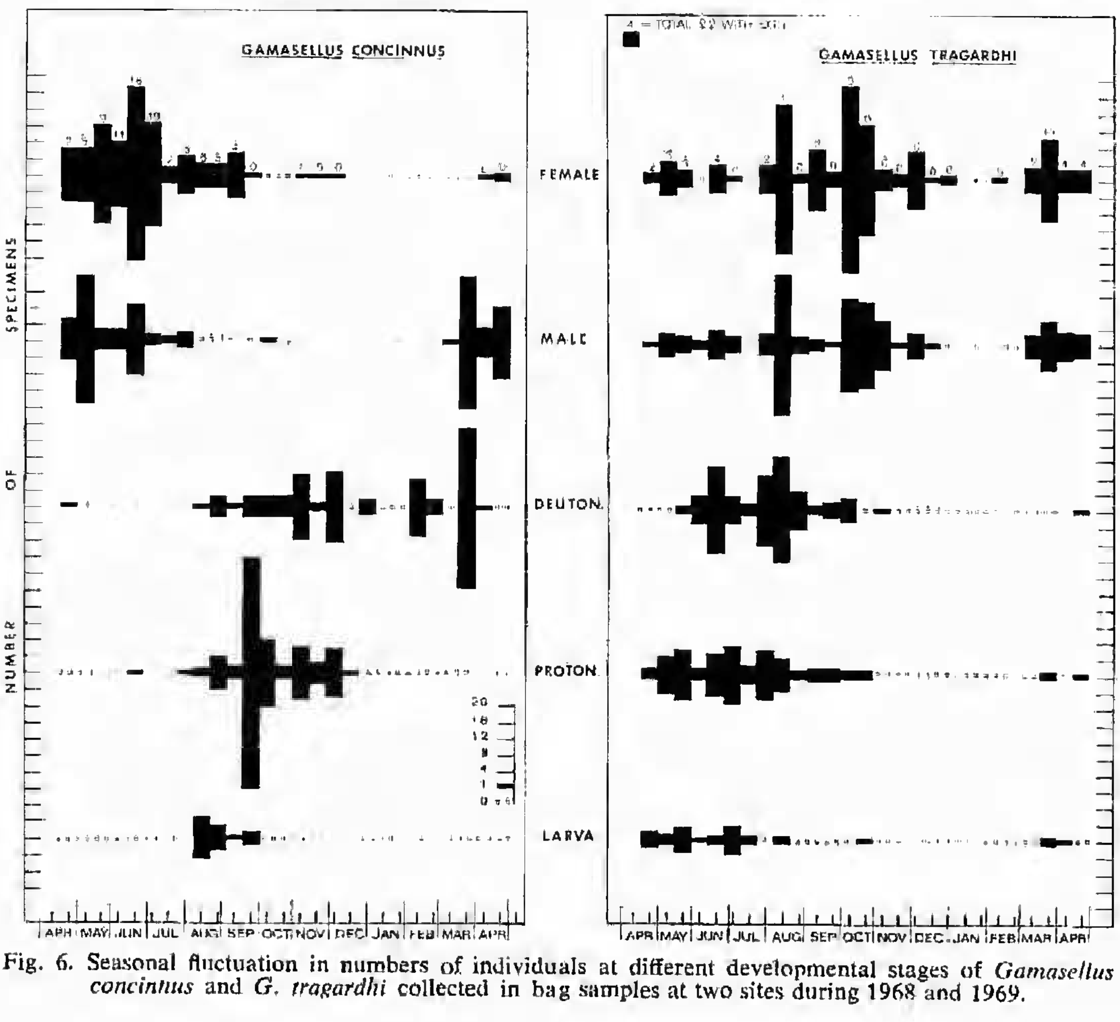

Fig. 6. Seasonal fluctuation in numbers of individuals at different developmental stages of *Gamasellus concinnus* and *G. tragardhi* collected in bag samples at two sites during 1968 and 1969.

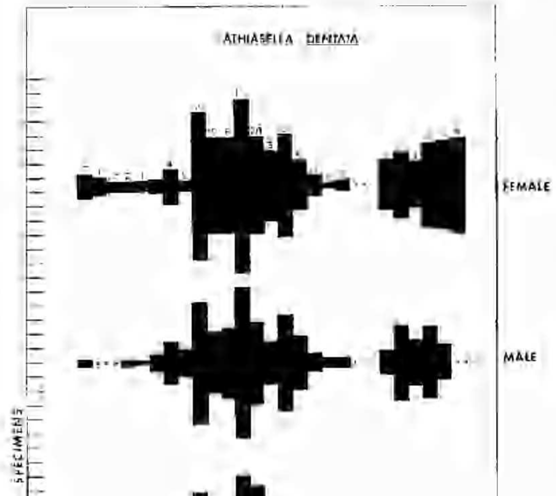

Fig. 7. Seasonal fluctuation in numbers of individuals at different developmental stages of *Athiasella dentata* collected in bag samples at two sites during 1968 and 1969.

different characteristic species and amongst members of the Ologamasinae there was a highly significant association between species characteristic of a site, thus demonstrating the presence of two rhodacarid communities.

Because serial samples were only taken from two sites (Summit and Foothills Sites), and environmental factors were not measured, it is impossible to confidently associate the rhodacarid taxa with particular factors in the environment. If, however, the few samples from the Plains and Coastal Sites are considered, there appears to be a similarity between the rhodacarid faunas of the Foothills and Plains Sites, in that *Athiasella* had the biggest representation, and between the Summit and Coastal Sites in that *Gamasellus* had the biggest representation. It appears, therefore, that the coastal sand dunes as well as the low nutrient, sandy soils near the summit of Mount Lofty are favourable to *Gamasellus* while the higher nutrient, loamy soils of the foothills and plain are not favourable. The converse appears to be true for *Athiasella*. Factors such as temperature and rainfall, which have a linear gradient between the coast and the summit of Mount Lofty, do not appear to be directly favourable or unfavourable to particular taxa. It is noteworthy that although the flora at the Foothills Site was introduced, mainly from outside Australia, the gamasine fauna was predominantly rhodacarid, with characteristic species that are probably all endemic to South Australia and belong to genera probably endemic to Australia.

Although the composition of the rhodacarid fauna of a particular site was similar in soil samples covered by litter and those covered by moss, a few species showed a distinct preference for one or the other habitat. Other attributes revealed for certain taxa were the tendency for species in the same genus to have similar sex ratios and the species of one genus, *Gamasellus*, to follow quite different life-histories.

Species of some genera (*Athiasella* and *Gamasellus*) were characteristic of one site, while for other genera (*Geogamasus*) this was not true. Conflicting hypotheses on species association were resolved by Bagenal (1951), who stated that "related species are more likely to be found in *similar*, though not identical, habitats than are unrelated ones". Hurlbutt (1968), working on species belonging to families closely allied to the rhodacarids, reached a similar conclusion expressed as "species which are very different anatomically or very similar anatomically coexist less often than species which are moderately similar to each other". Certainly the three species of *Gamasellus* associated at the Summit Site are as dissimilar (see Fig. 2) from each other as it is possible to select from known species of *Gamasellus* and would probably be considered by Hurlbutt (1968) as 'moderately similar'. They must exploit different ecological niches within the volume of the small cores in which they were collected. The same is likely, although not so clear-cut for the two species of *Athiasella*.

The very slight but easily discernable morphological difference between *Gamasellus tragardhi* from the Summit Site and *Gamasellus grossi* from the Coastal Site (Lee 1973) suggests that the level of taxonomic distinction is closely associated with ease of anatomical diagnosis rather than genetic similarity. The *Rhodacarus* specimen from the Summit Site is possibly equally dissimilar to the *Rhodacarus* specimens from the Plains Site (Lee 1973), both of which I have referred to *R. roseus*. I suspect that many mite species which show limited distribution in widely differing geographical locations (see Introduction) are also grouped in one species because of difficulties in diagnosis.

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Appendix: Details of Sampling Sites and Plots

Summit Site. Location: Mt. Lofty, near to summit, approx. 18 km from the sea. Australian Map Grid co-ordinates: 290600 m E/6127230 m N, map no. 6628-48-j, Dept. of Lands, Adelaide. Height above sea level: 640–670m. Rainfall: mean annual rainfall approx. 120 cm.; figures used in graph (Fig. 5) are for Stirling (5 km SSE of site) with a mean annual rainfall of 119.0 cm, and a total rainfall in 1968 of 161.6 cm; it should be noted that "a large percentage of rainfall is lost to the soil by run-off in the Adelaide Hills" (Specht & Perry 1948). Temperature: mean monthly min./max. temperatures for Stirling are January, 11.5°/24.5°C; July, 4.5°/10.5°C. Terrain: steep western slope of hill, near to summit. Soil: Black Hill Association—"low nutrient reserves in most soils in which shallow depth is the chief limiting physical characteristic" (Litchfield 1960); shallow (10–35 cm), dark grey, loamy sand; an analysis of soil from Mt. Lofty Summit showed 0.0044% P_2O_5 and 0.040% Nitrogen (Specht & Perry 1948). Vegetation: open-forest of Stringy Bark—*Eucalyptus obliqua* L'Hérit.—with a sclerophyllous understorey of small native heath shrubs including *Banksia ornata* F.v.M. ex Meisn., *Epacris impressa* Labill. and *Leptospermum juniperinum* Sm. Fifteen other species of native shrubs, herbs or grasses were collected from the site.

General Summit Plot (Sc1). A sub-rhomboid area (approximately 19 x 12 m) which constituted a clearing amongst charred trees with a drainage channel running through the centre. A fire had passed through the plot three years before (February, 1966). The eastern half of the clearing had substantial vegetation, including abundant fireweed—*Ixodia achilleoides* R. Br. ex Ait., a short-lived, "high-fertility-demanding" species depending on the temporary rise in fertility-level due to the ashes of the burnt vegetation (Specht 1972). The western half of the clearing had a sparse vegetation of heath shrub seedlings and extensive patches of moss. Plant litter was almost absent from the mossy half of the clearing, but had accumulated as raw leaves and twigs around the bases of tree stumps, fallen branches and small shrubs in the other half. Bag samples were collected from this plot.

Summit Moss Plot (S1). A rectangular area (2 x 10 m) lying approximately at the centre of the western half of plot Sc1. Covered almost entirely by a mat of moss. All core samples, and after August some of the bag samples, were collected from this plot.

Summit Litter Plot (S2). A rectangular area (2 x 10 m) lying approximately 20 m east of plot Sc1, and separated from it by a bitumen road. No fire had been through the plot for 25 years. Understorey was thick with heath shrubs and decomposing plant litter (mainly 1.0 cm deep) covered most of the ground. Only core samples were collected from this plot.

Foothills Site. Location: Foothills of Mt. Lofty, approx. 16 km from the sea. Australian Map Grid co-ordinates: 288230 m E/6127620 m N, map no. 6628-49-e, Dept. of Lands, Adelaide. Height above sea level: 240–270 m. Rainfall: mean annual rainfall is approx. 94.0 cm. Temperature: mean monthly min./max. temperatures for Glen Osmond (5 km W of site) are January, 16°/28°C; July, 7°/15°C. Terrain: bottom of steep northern slope (south-facing aspect of ridge) of Waterfall Gully, just west of First Waterfall, beside an artificial pond formed by dredging and damming First Creek. Soil: Osmond Association—"Nutrient reserves . . . . presumably intermediate between low levels . . . and the moderate levels in the red brown earths of the piedmont aprons" (Litchfield 1960); shallow to deep (35-110 cm), alluvial red-brown loam, artificially moved to present position, possibly from creek bed. Vegetation: alien (as it mainly is on bottom 15–20 m of slope downstream from this point, further up slope from site there are Manna Gums—*Eucalyptus viminalis* var. *huberiana* (Naudin) Burbridge—and Drooping Sheoaks—*Casuarina stricta* Ait.); Fan-leaved palms (*Livistonia* sp.), Olives (*Olea europaea* L.), Lilacs (*Syringa vulgaris* L.) and *Pittosporum undulatum* Vent. (native of eastern states); understorey of brambles, bracken and five species of herbs and grasses; only native plant found was a small herb—*Geranium pilosum* Forst.

General Foothills Plot (Fc1). A sub-rectangular area (approx. 20 x 8 m) which constituted a patch of quite thick alien vegetation on the north bank of the pond. Although the bank was steep, the understorey held the plant litter in most places, but where the bank was very steep, or the ground stony, there was little or no litter and moss or liverworts grew. Bag samples were collected from this plot.

Foothills Litter Plot (F1). A rectangular area (2 x 10 m) lying approx. at the centre of plot Fc1. Covered by plant litter (Olive leaves predominated, mainly 2.0 cm deep) and some herbs and grass tussocks. All core samples, and after August some of the bag samples, were collected from this plot.

Foothills Moss Plot (F2). A rectangular area (2 x 10 m) lying approx. 10 m west of plot Fc1, and separated from it by an artificially channelled creek bed, which was steep and usually dry. Some soil bare but mostly covered by moss or liverworts. Under a row of small trees (*Pittosporum undulatum*) evenly planted along the west bank of the creek. Only core samples were collected from this plot.

Plains Site. Location: Heywood Park, Unley, on the Adelaide Plain, approx. 8 km from the sea. Australian Map Grid co-ordinates: 280810 m E 6128350 m N, map no. 6628-50-e, Dept of Lands, Adelaide. Height above sea level: 30-60 m. Rainfall: approx. 58 cm/year. Temperature: January, 16.5°/29.5°C, July, 6.5°/14.5°C. Terrain: small, flat suburban park, with tall trees surrounding clearing. Soil: Edwardstown Association; red-brown loam. Vegetation: savannah woodland of River Red Gums—*Eucalyptus camaldulensis* Dehnh.—"is confined to grey-brown podsols on the slopes and ridges and alluvial soils in the valleys, both soils being rich in P_2O_5 and nitrogen and having high water relations" (Specht & Perry 1948); understorey of grass amongst patches of *Eucalyptus* litter. Samples from patches of litter under River Red Gums.

Coastal Site. Location: "Pinery", Grange Golf Course, near coast of Adelaide Plain, approx. 1.5 km from the sea. Australian Map Grid co-ordinates: 271310 m E/6137040 m N, map no. 6528-36-m, Dept. of Lands, Adelaide. Height above sea level: 0-30 m. Rainfall: approx. 43 cm/year, "greens" artificially watered. Temperature: January, 15°/28°C; July 6.5°/15°C. Terrain: inland relicts of coastal dunes formed in Pleistocene Period, modified to a golf course. Soil: Osborne Association; calcareous sand in which the soluble calcium bicarbonate has been leached to lower horizons. Vegetation: low woodland of Native Pines—*Callitris preissii* Miq.—with understorey of moss and sparse grass, on dune ridges, amongst artificial grass greens; "a 'degraded' climax plant community characteristic of infertile, non-calcareous, sandy soils" (Specht 1972). Samples from moss mats under Native Pines.